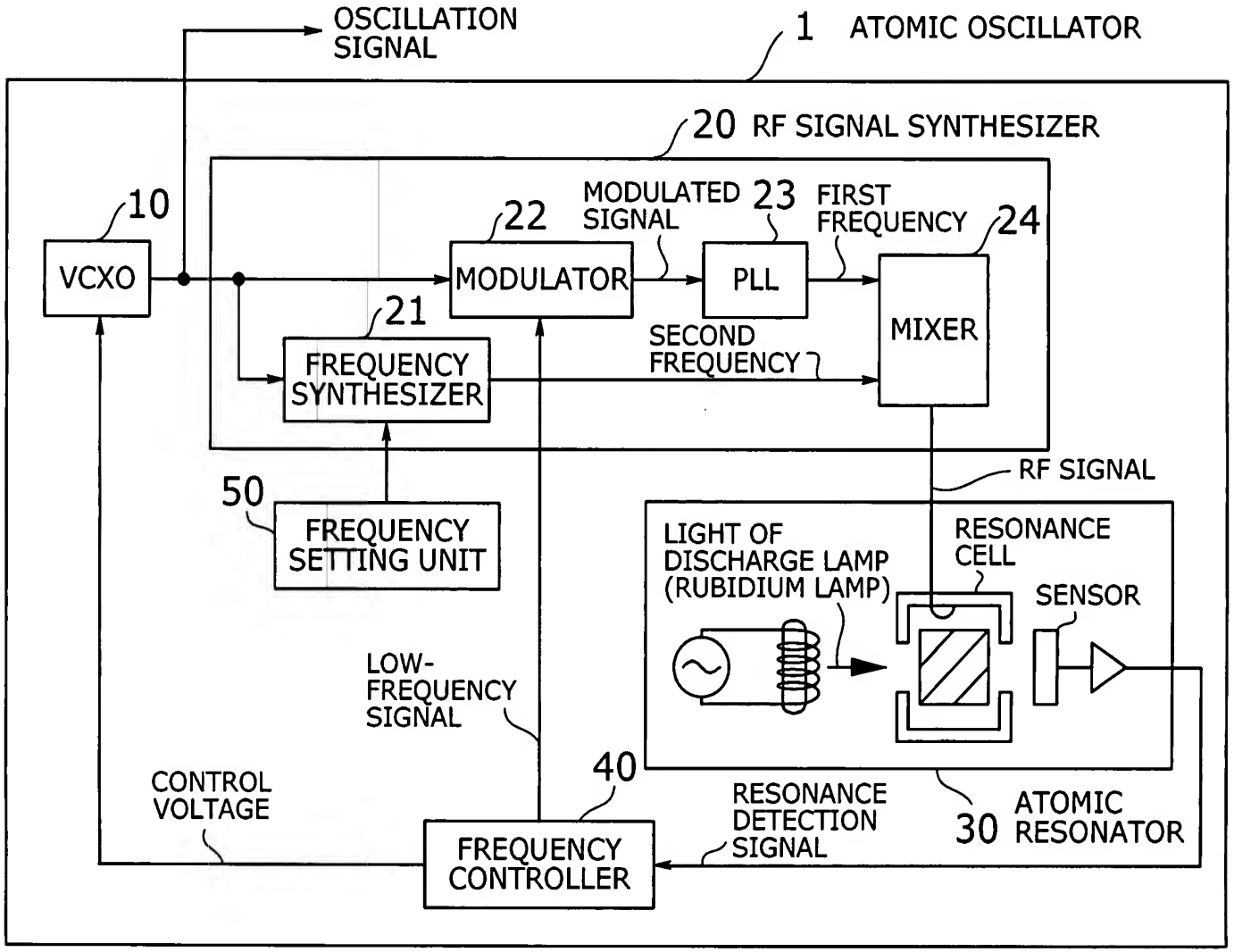
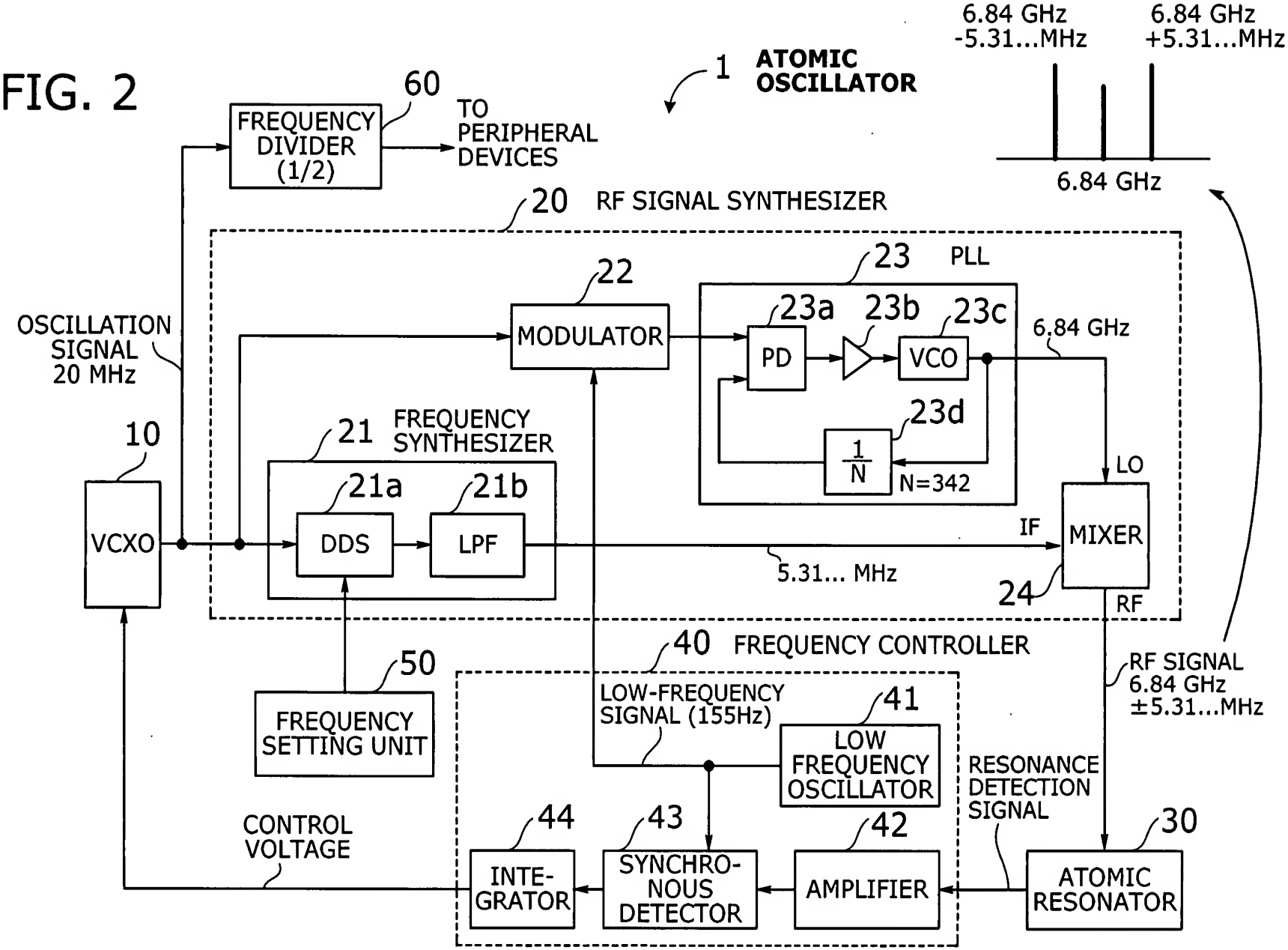

OSCILLATION SIGNAL
1 ATOMIC OSCILLATOR
20 RF SIGNAL SYNTHESIZER
10
VCXO
22
MODULATOR
MODULATED SIGNAL
23
PLL
FIRST FREQUENCY
24
MIXER
21
FREQUENCY SYNTHESIZER
SECOND FREQUENCY
RF SIGNAL
50
FREQUENCY SETTING UNIT
LIGHT OF DISCHARGE LAMP (RUBIDIUM LAMP)
RESONANCE CELL
SENSOR
LOW-FREQUENCY SIGNAL
40
CONTROL VOLTAGE
RESONANCE DETECTION SIGNAL
30 ATOMIC RESONATOR
FREQUENCY CONTROLLER

FIG. 1

FIG. 2


6.84 GHz
-5.31...MHz
6.84 GHz
+5.31...MHz
6.84 GHz
1
ATOMIC OSCILLATOR
60
FREQUENCY DIVIDER (1/2)
TO PERIPHERAL DEVICES
20
RF SIGNAL SYNTHESIZER
22
MODULATOR
23
PLL
23a
23b
23c
PD
VCO
6.84 GHz
23d
1/N
N=342
OSCILLATION SIGNAL 20 MHz
10
VCXO
21
FREQUENCY SYNTHESIZER
21a
21b
DDS
LPF
LO
IF
MIXER
5.31... MHz
24
RF
40
FREQUENCY CONTROLLER
50
FREQUENCY SETTING UNIT
LOW-FREQUENCY SIGNAL (155Hz)
41
LOW FREQUENCY OSCILLATOR
RF SIGNAL 6.84 GHz ±5.31...MHz
RESONANCE DETECTION SIGNAL
CONTROL VOLTAGE
44
43
42
30
INTE-GRATOR
SYNCHRO-NOUS DETECTOR
AMPLIFIER
ATOMIC RESONATOR

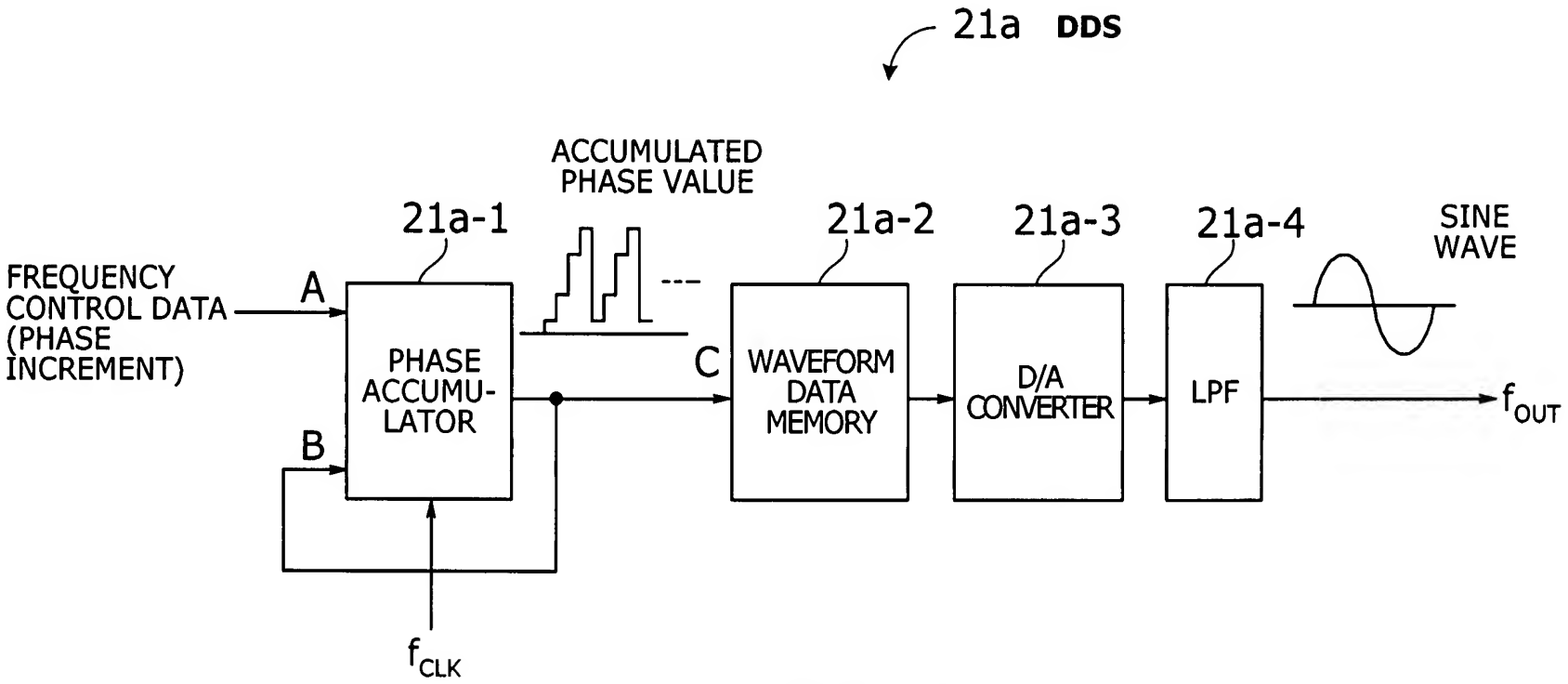

21a DDS
ACCUMULATED PHASE VALUE
21a-1
21a-2
21a-3
21a-4
SINE WAVE
FREQUENCY CONTROL DATA (PHASE INCREMENT)
A
B
PHASE ACCUMU-LATOR
C
WAVEFORM DATA MEMORY
D/A CONVERTER
LPF
f_{OUT}
f_{CLK}

FIG. 3

T1

CLOCK COUNT	ACCUMULATED PHASE OUTPUT				
	BIT #3	BIT #2	BIT #1	BIT #0	DECIMAL
0	0	0	0	0	0
1	0	0	1	1	3
2	0	1	1	0	6
3	1	0	0	1	9
4	1	1	0	0	12
5	1	1	1	1	15
6	0	0	1	0	2
7	0	1	0	1	5
8	1	0	0	0	8
9	1	0	1	1	11
10	1	1	1	0	14
11	0	0	0	1	1
12	0	1	0	0	4
13	0	1	1	1	7
14	1	0	1	0	10
15	1	1	0	1	13
16	0	0	0	0	0
17	0	0	1	1	3
18	0	1	1	0	6
19	1	0	0	1	9

FIG. 4

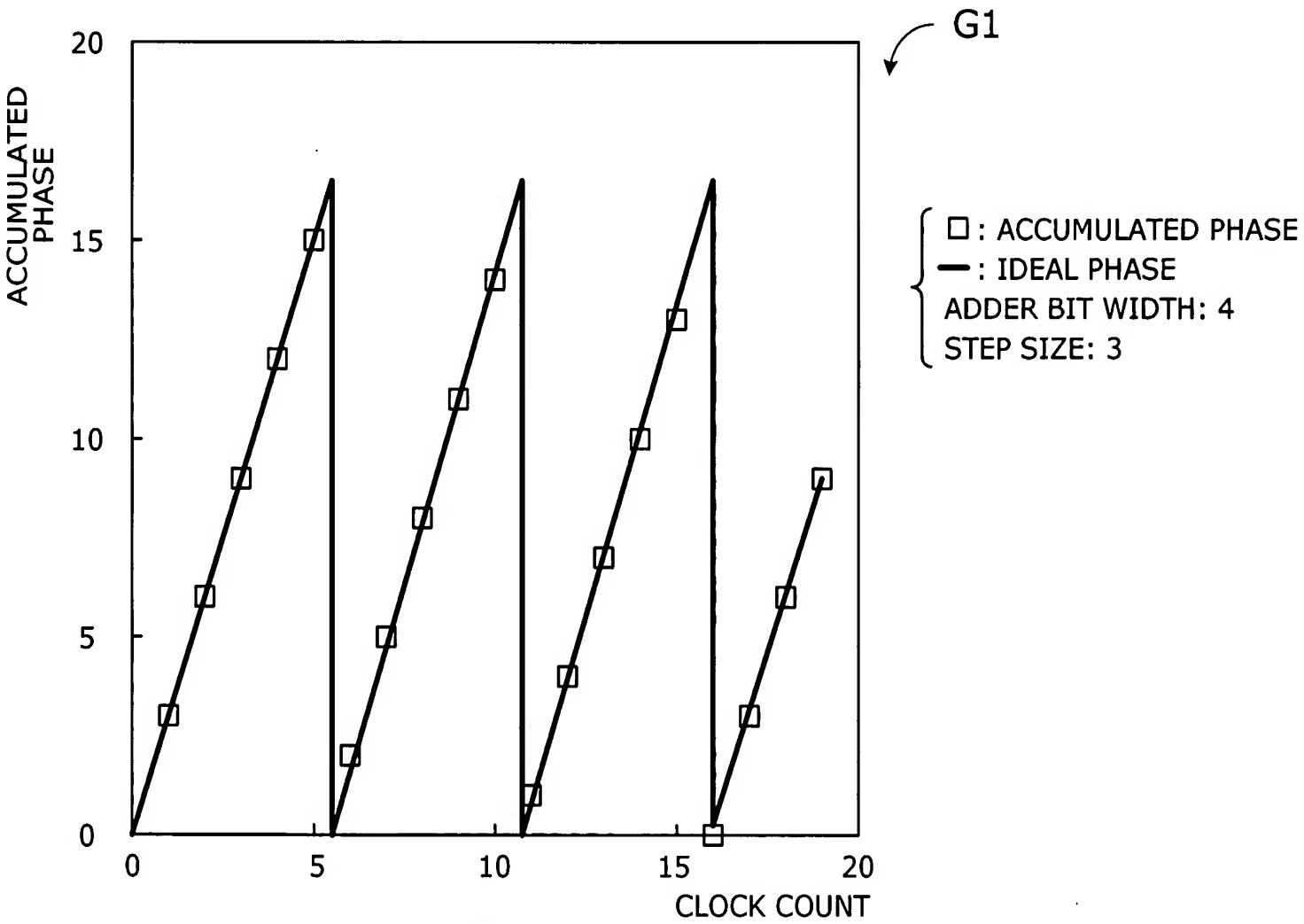

G1
ACCUMULATED PHASE
20
15
10
5
0
0
5
10
15
20
CLOCK COUNT
□ : ACCUMULATED PHASE
— : IDEAL PHASE
ADDER BIT WIDTH: 4
STEP SIZE: 3

FIG.5

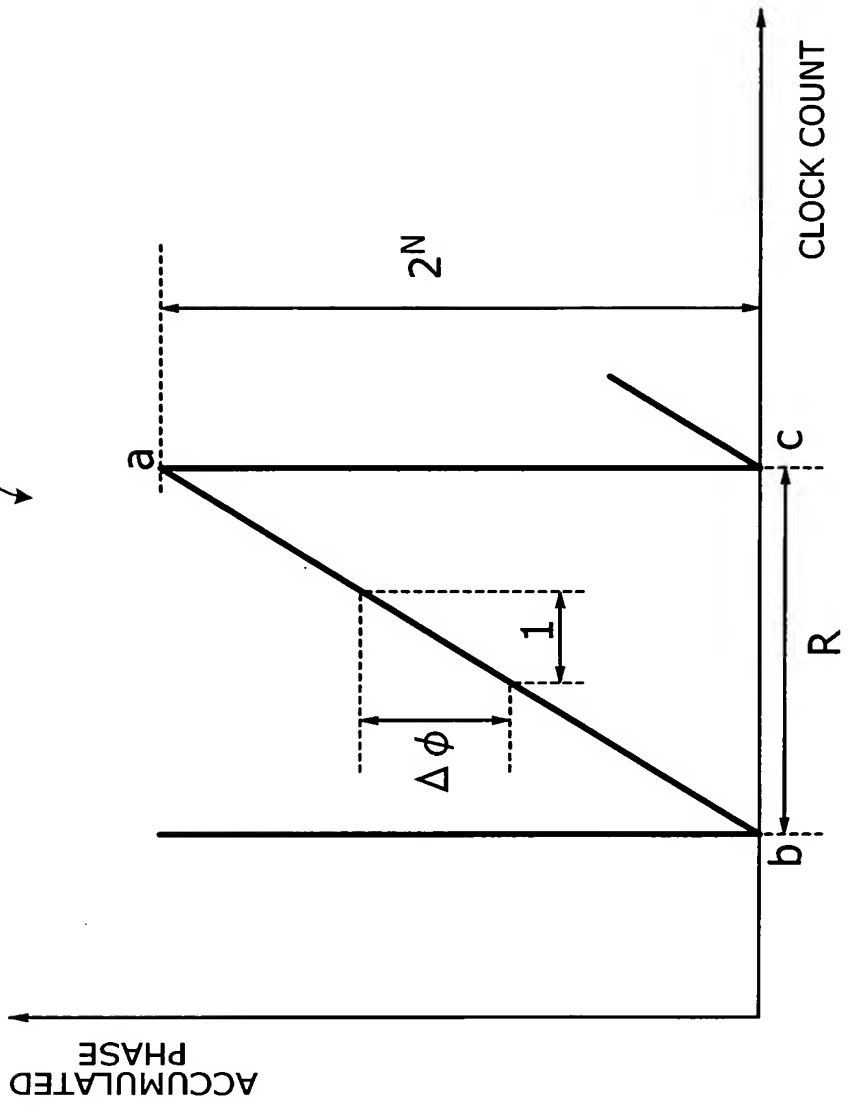


FIG. 6

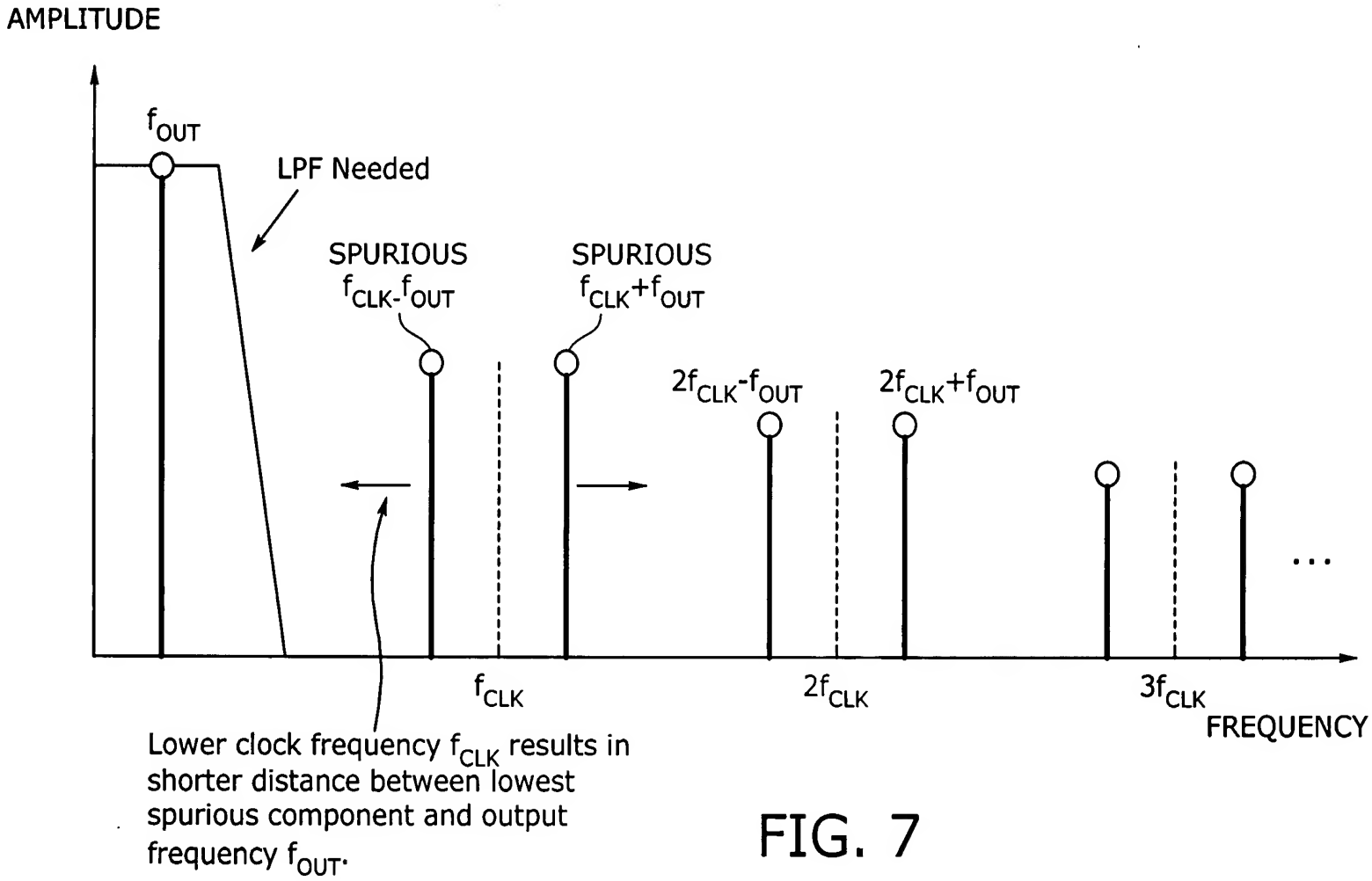

AMPLITUDE
f_{OUT}
LPF Needed
SPURIOUS
$f_{CLK}-f_{OUT}$
SPURIOUS
$f_{CLK}+f_{OUT}$
$2f_{CLK}-f_{OUT}$
$2f_{CLK}+f_{OUT}$
...
f_{CLK}
$2f_{CLK}$
$3f_{CLK}$
FREQUENCY
Lower clock frequency f_{CLK} results in shorter distance between lowest spurious component and output frequency f_{OUT}.

FIG. 7

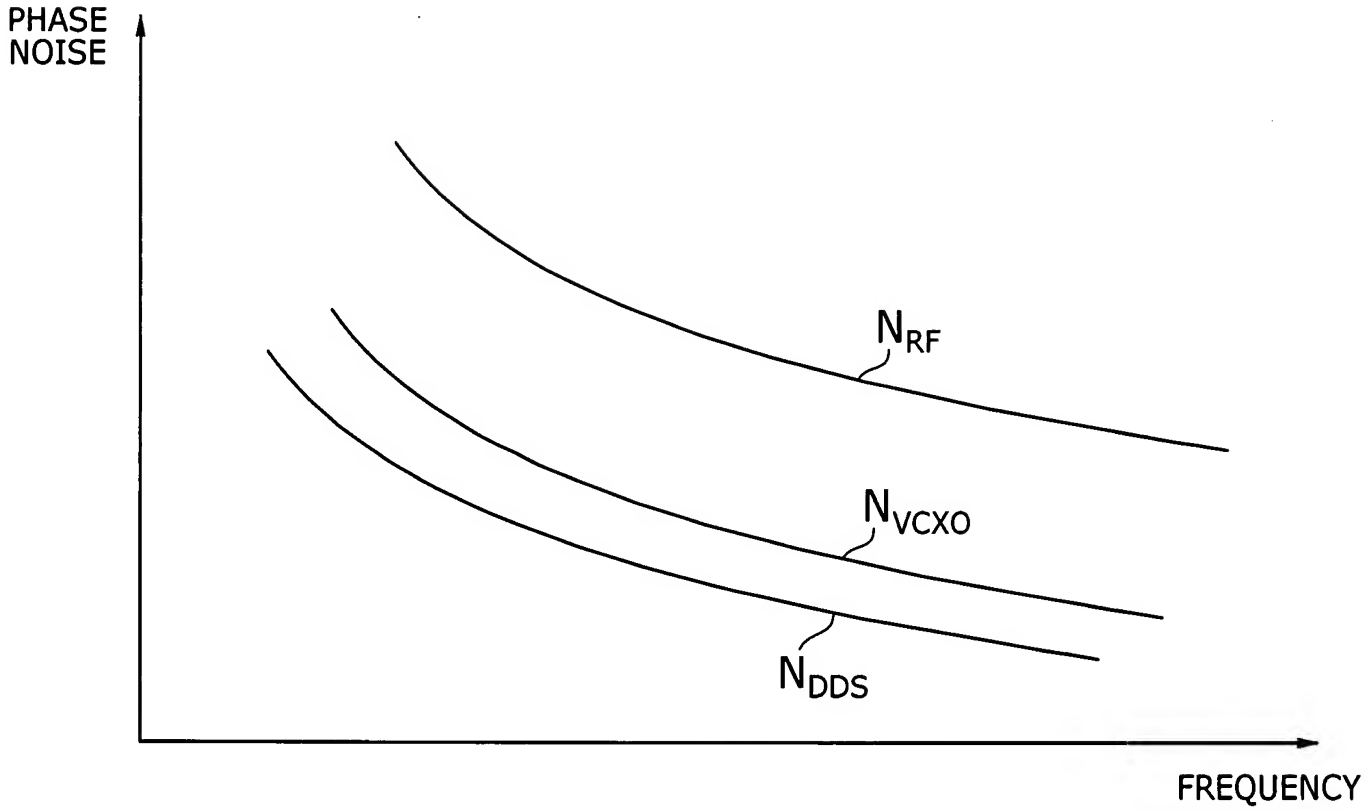


FIG. 8

PRIOR ART

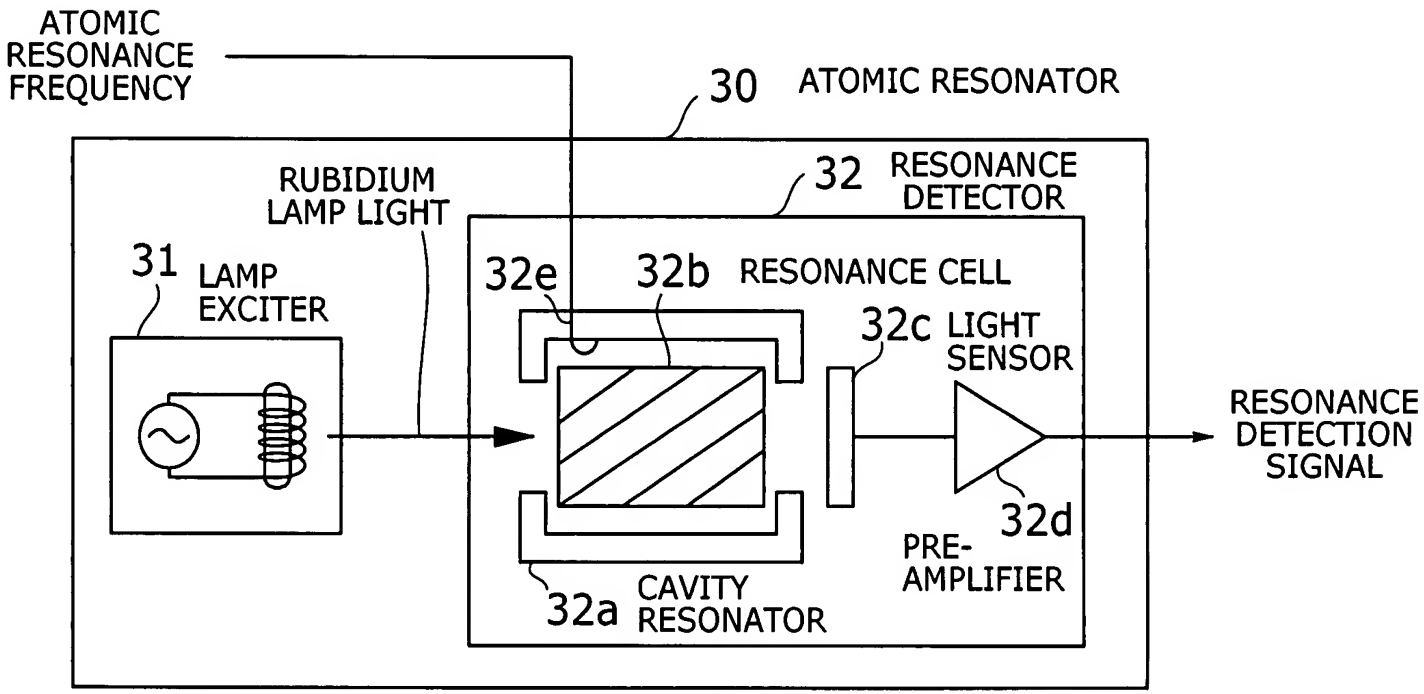

ATOMIC
RESONANCE
FREQUENCY
30 ATOMIC RESONATOR
32 RESONANCE
DETECTOR
RUBIDIUM
LAMP LIGHT
31 LAMP
EXCITER
32e
32b RESONANCE CELL
32c LIGHT
SENSOR
RESONANCE
DETECTION
SIGNAL
32d
PRE-
AMPLIFIER
32a CAVITY
RESONATOR

FIG. 9

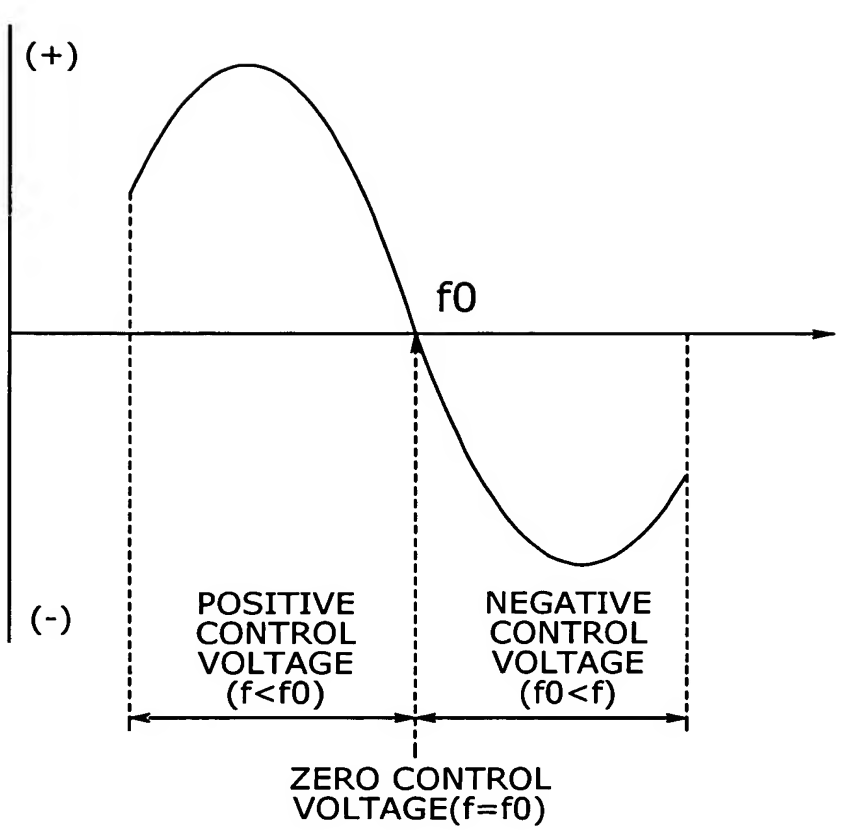
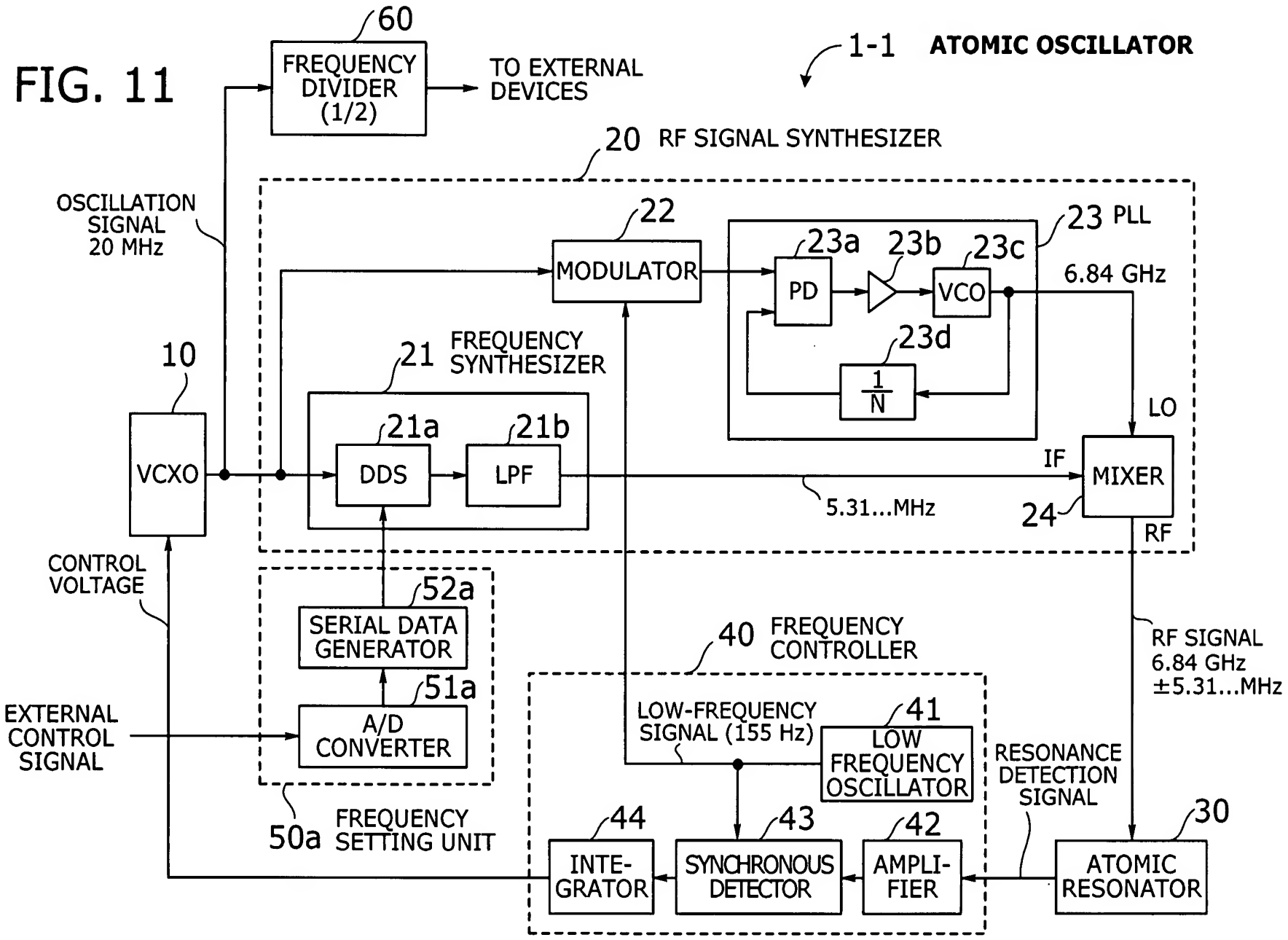

(+)
f0
(-)
POSITIVE CONTROL VOLTAGE (f<f0)
NEGATIVE CONTROL VOLTAGE (f0<f)
ZERO CONTROL VOLTAGE(f=f0)

FIG. 10

FIG. 11


1-1 ATOMIC OSCILLATOR
60
FREQUENCY DIVIDER (1/2)
TO EXTERNAL DEVICES
20 RF SIGNAL SYNTHESIZER
OSCILLATION SIGNAL 20 MHz
22
MODULATOR
23 PLL
23a
23b
23c
PD
VCO
6.84 GHz
23d
1/N
10
21 FREQUENCY SYNTHESIZER
21a
21b
VCXO
DDS
LPF
LO
IF
MIXER
24
5.31...MHz
RF
CONTROL VOLTAGE
52a
SERIAL DATA GENERATOR
40 FREQUENCY CONTROLLER
RF SIGNAL 6.84 GHz ±5.31...MHz
51a
EXTERNAL CONTROL SIGNAL
A/D CONVERTER
LOW-FREQUENCY SIGNAL (155 Hz)
41
LOW FREQUENCY OSCILLATOR
RESONANCE DETECTION SIGNAL
50a FREQUENCY SETTING UNIT
44
43
42
30
INTE-GRATOR
SYNCHRONOUS DETECTOR
AMPLI-FIER
ATOMIC RESONATOR

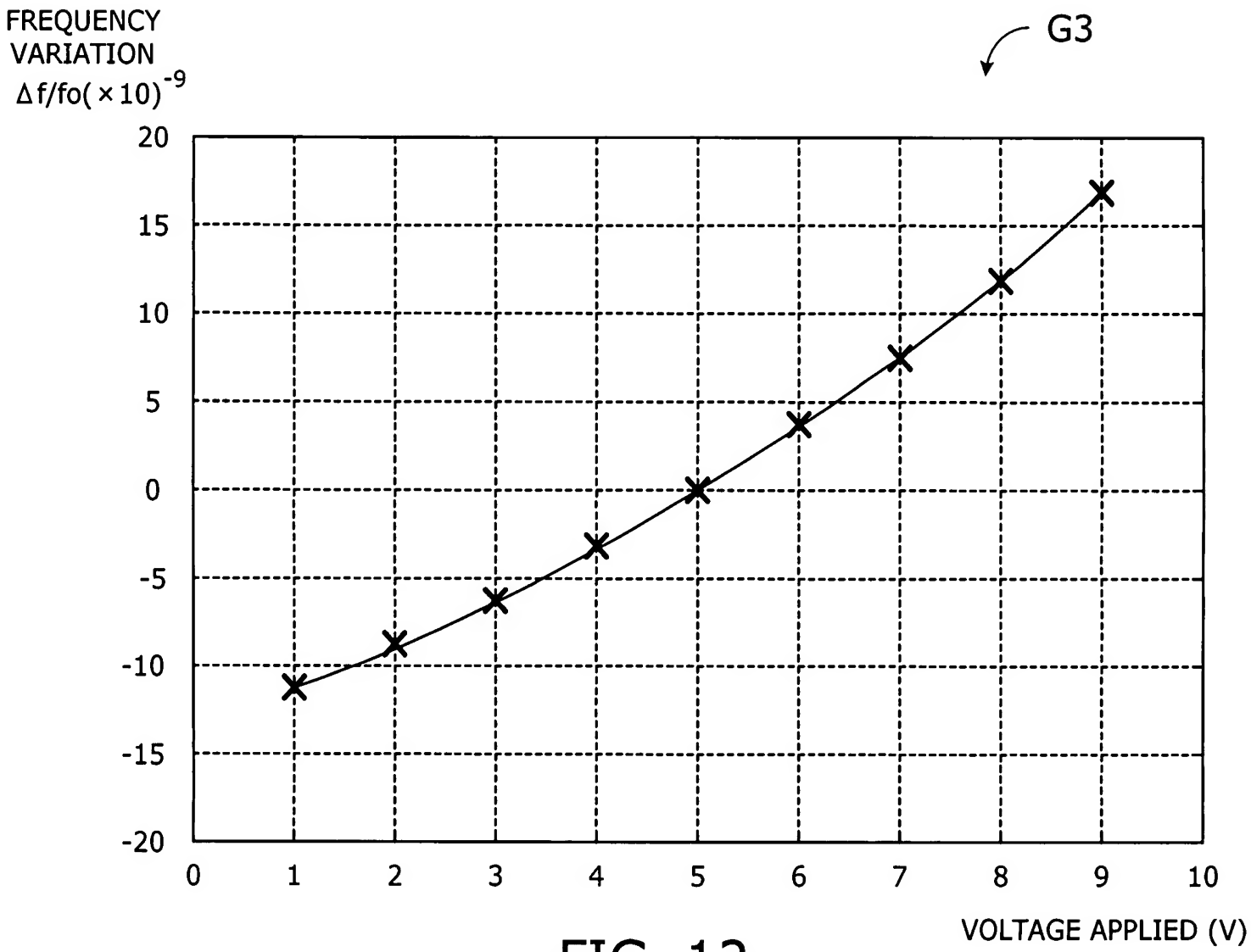

FREQUENCY
VARIATION
Δf/fo(×10)-9
G3
20
15
10
5
0
-5
-10
-15
-20
0
1
2
3
4
5
6
7
8
9
10
VOLTAGE APPLIED (V)

FIG. 12

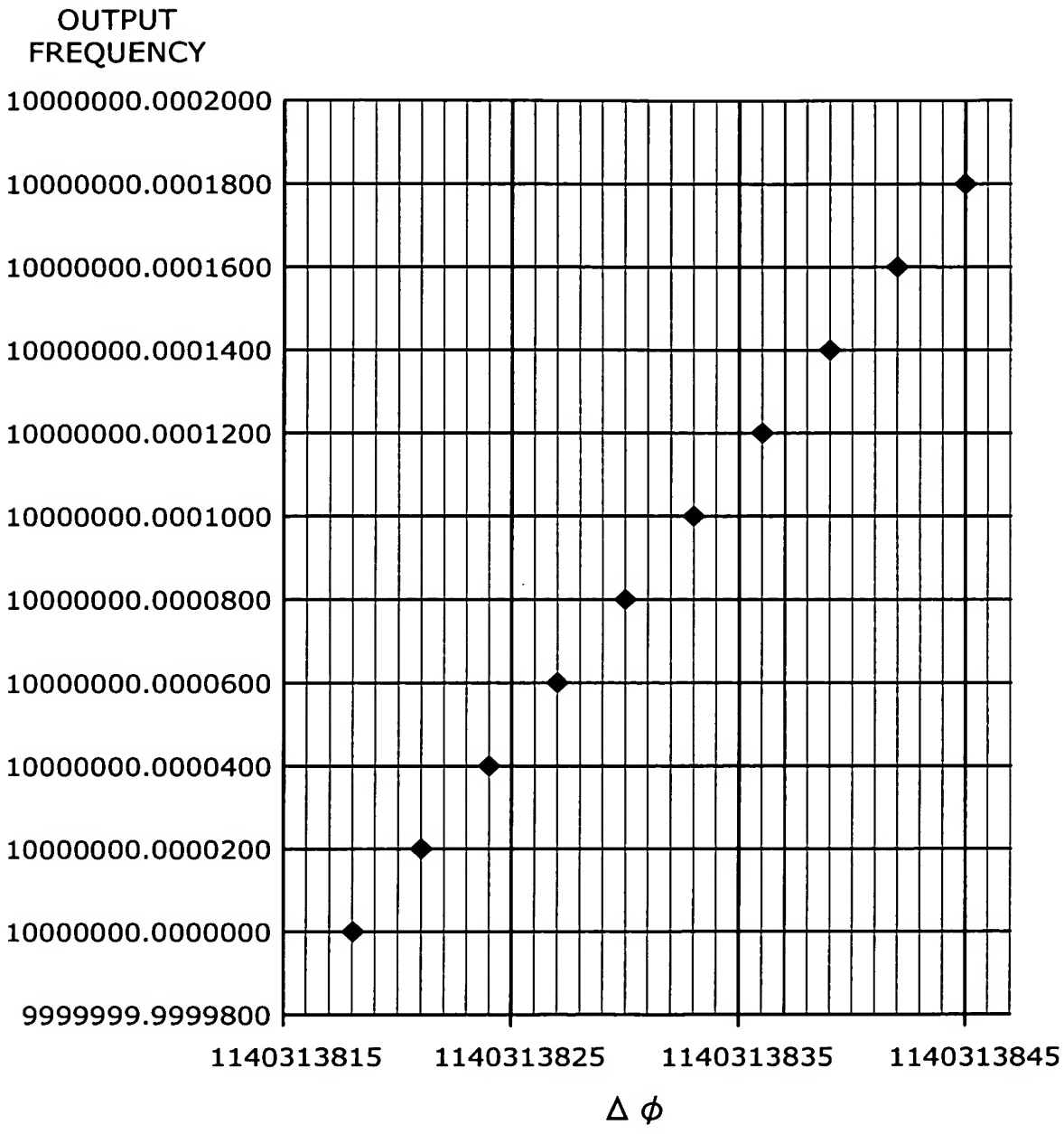

OUTPUT
FREQUENCY
10000000.0002000
10000000.0001800
10000000.0001600
10000000.0001400
10000000.0001200
10000000.0001000
10000000.0000800
10000000.0000600
10000000.0000400
10000000.0000200
10000000.0000000
9999999.9999800
1140313815
1140313825
1140313835
1140313845
Δ φ

FIG. 13

FIG. 14

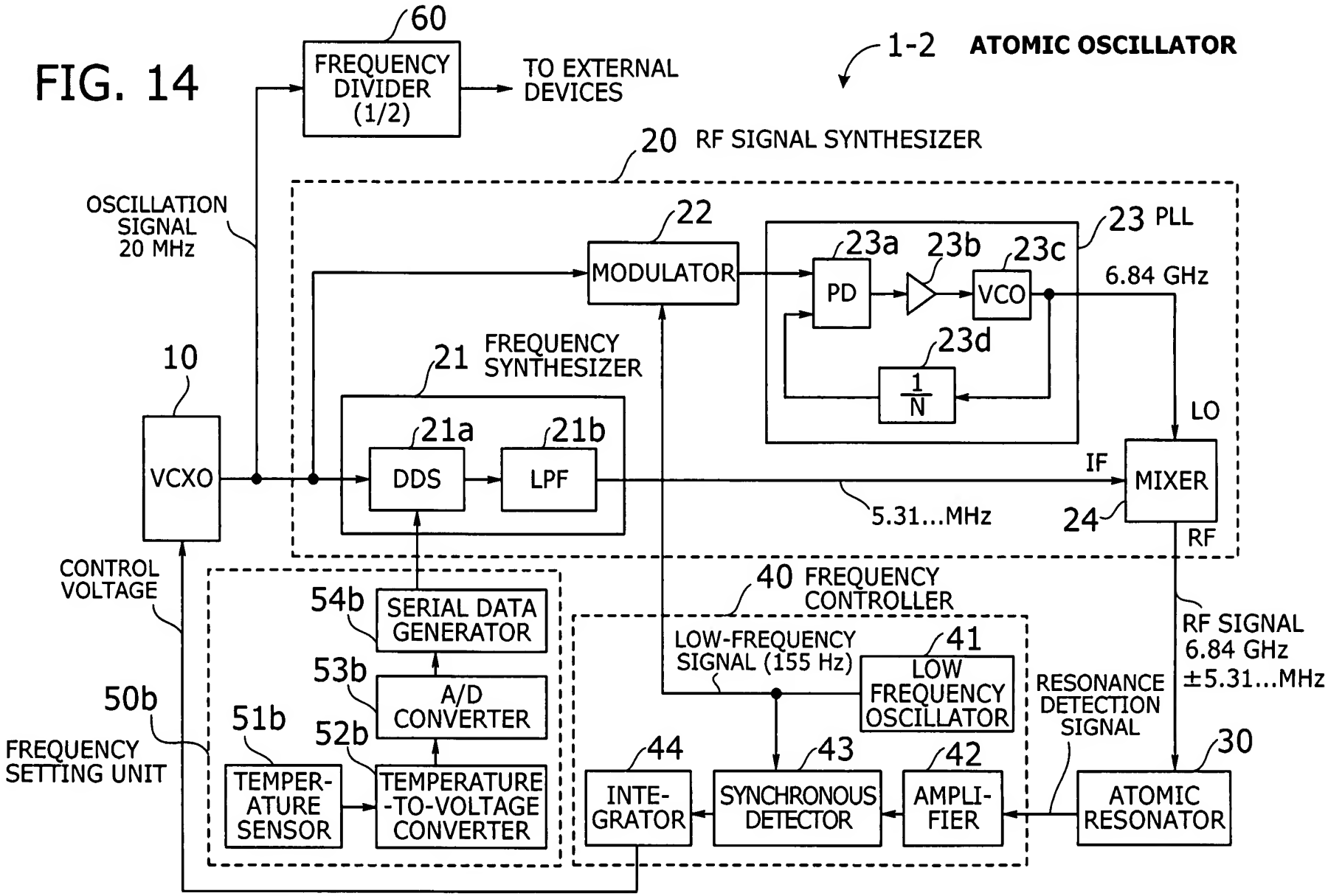
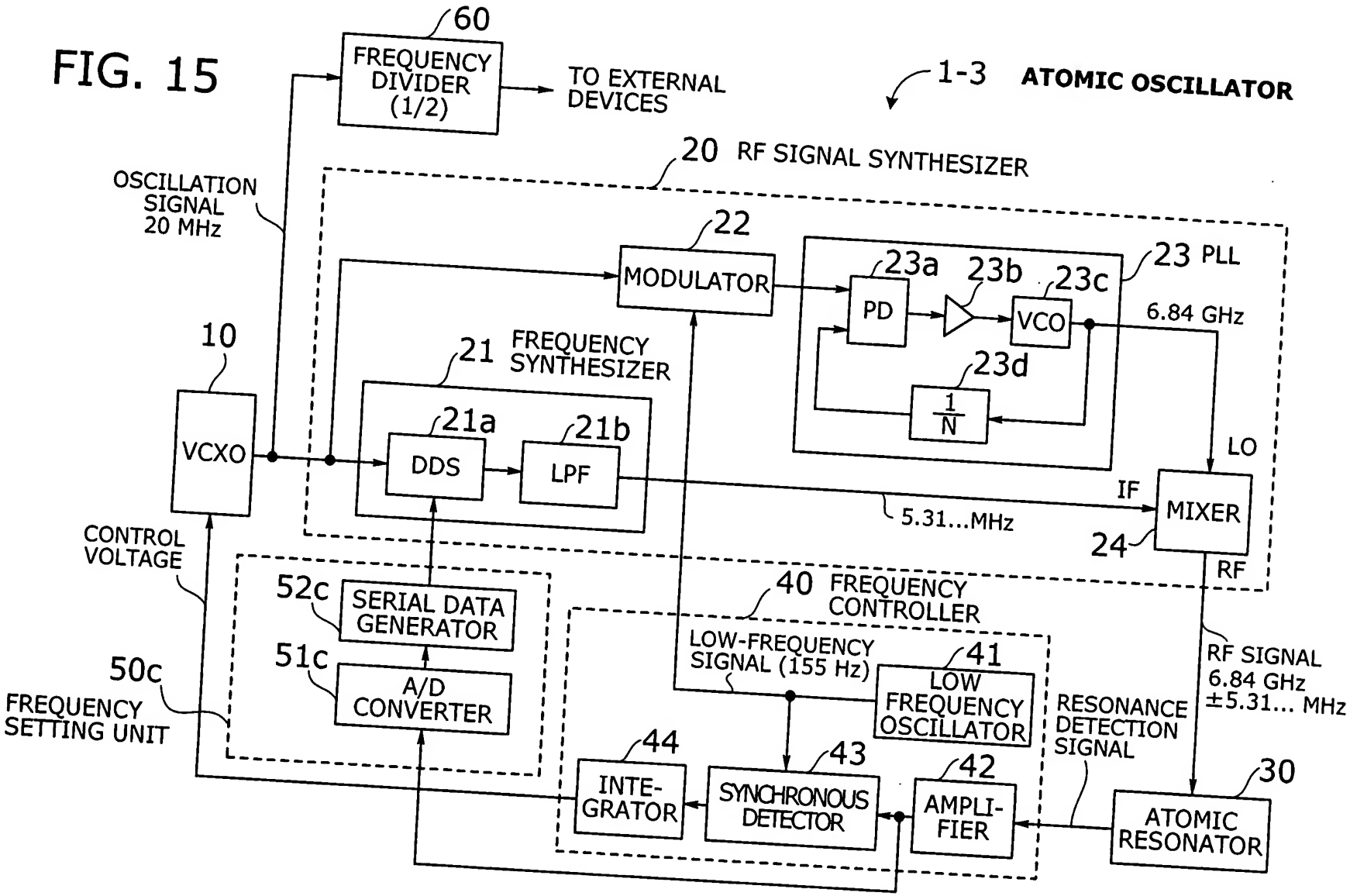

1-2 ATOMIC OSCILLATOR
60
FREQUENCY DIVIDER (1/2)
TO EXTERNAL DEVICES
20 RF SIGNAL SYNTHESIZER
OSCILLATION SIGNAL 20 MHz
22
MODULATOR
23 PLL
23a
23b
23c
PD
VCO
6.84 GHz
23d
1/N
10
21 FREQUENCY SYNTHESIZER
21a
21b
DDS
LPF
VCXO
LO
IF
MIXER
24
5.31...MHz
RF
CONTROL VOLTAGE
40 FREQUENCY CONTROLLER
54b
SERIAL DATA GENERATOR
LOW-FREQUENCY SIGNAL (155 Hz)
41
LOW FREQUENCY OSCILLATOR
RF SIGNAL 6.84 GHz ±5.31...MHz
53b
A/D CONVERTER
50b
51b
52b
RESONANCE DETECTION SIGNAL
FREQUENCY SETTING UNIT
TEMPER-ATURE SENSOR
TEMPERATURE-TO-VOLTAGE CONVERTER
44
43
42
30
INTE-GRATOR
SYNCHRONOUS DETECTOR
AMPLI-FIER
ATOMIC RESONATOR

FIG. 15


60
FREQUENCY DIVIDER (1/2)
TO EXTERNAL DEVICES
1-3 ATOMIC OSCILLATOR
20 RF SIGNAL SYNTHESIZER
OSCILLATION SIGNAL 20 MHz
22
MODULATOR
23a
23b
23c
23 PLL
PD
VCO
6.84 GHz
23d
1/N
10
21 FREQUENCY SYNTHESIZER
VCXO
21a
21b
DDS
LPF
LO
IF
5.31...MHz
MIXER
24
RF
CONTROL VOLTAGE
52c
SERIAL DATA GENERATOR
40 FREQUENCY CONTROLLER
LOW-FREQUENCY SIGNAL (155 Hz)
41
LOW FREQUENCY OSCILLATOR
RF SIGNAL 6.84 GHz ±5.31... MHz
50c
51c
A/D CONVERTER
FREQUENCY SETTING UNIT
RESONANCE DETECTION SIGNAL
44
43
42
30
INTE-GRATOR
SYNCHRONOUS DETECTOR
AMPLI-FIER
ATOMIC RESONATOR

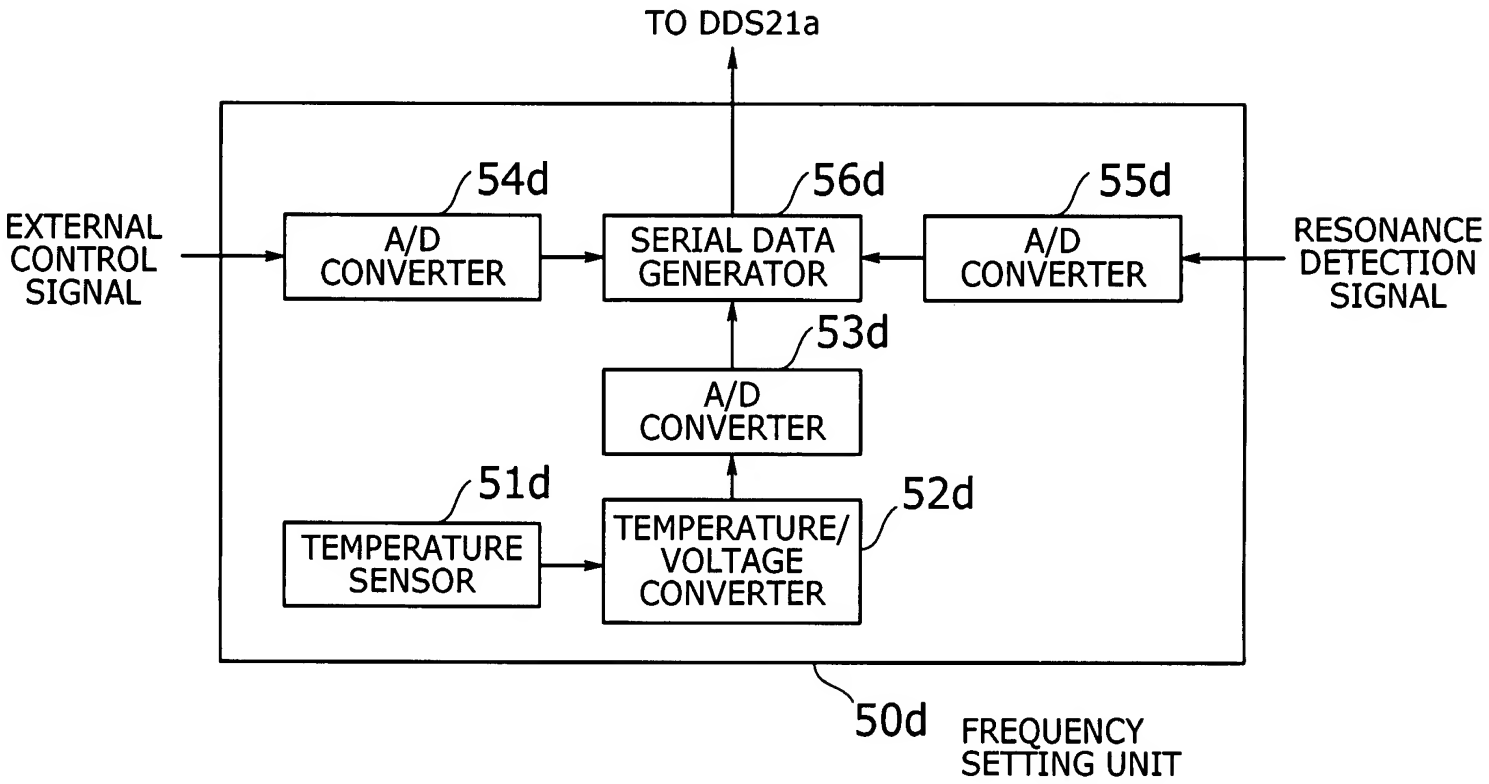
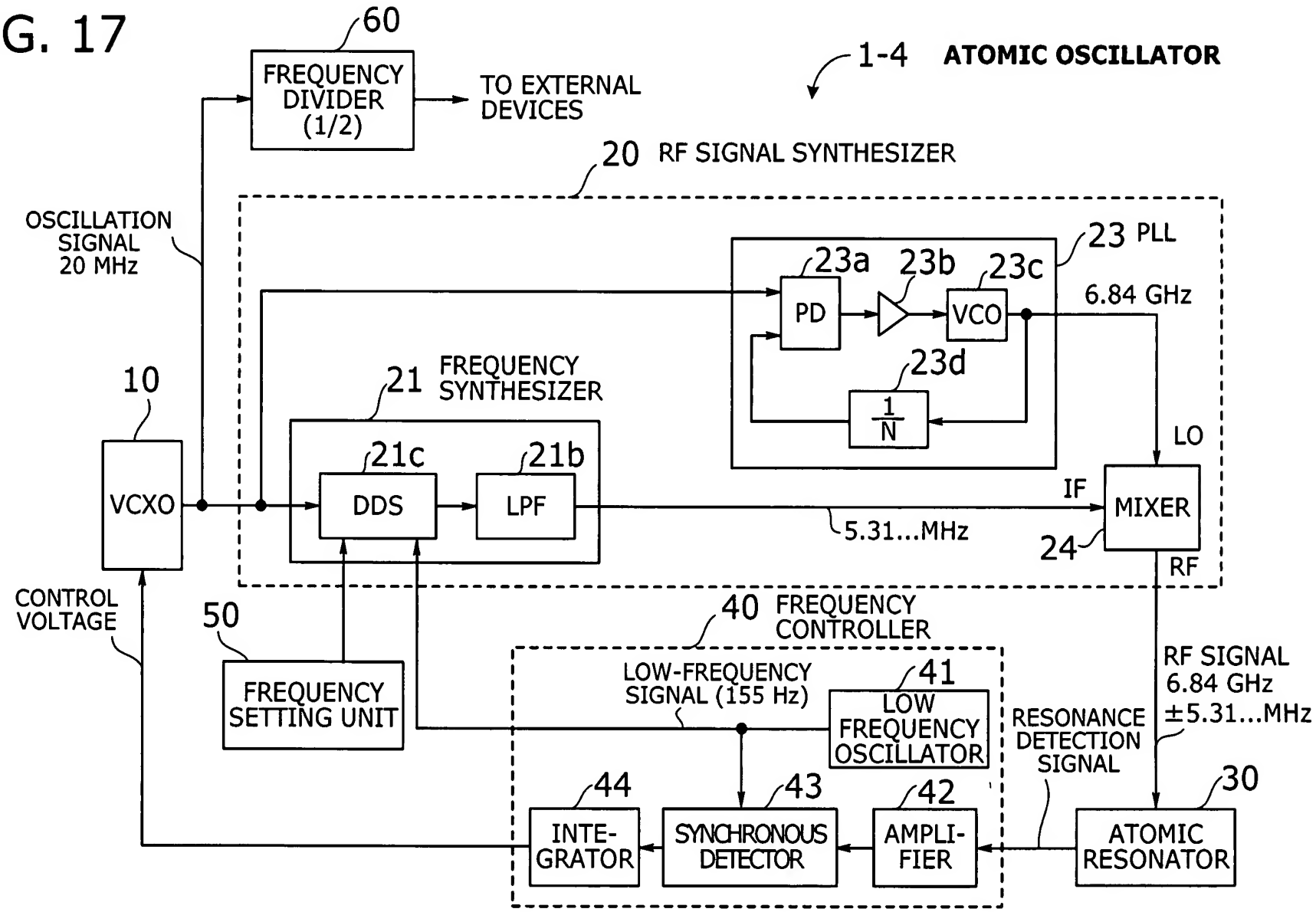

TO DDS21a
54d
56d
55d
EXTERNAL CONTROL SIGNAL
A/D CONVERTER
SERIAL DATA GENERATOR
A/D CONVERTER
RESONANCE DETECTION SIGNAL
53d
A/D CONVERTER
51d
52d
TEMPERATURE SENSOR
TEMPERATURE/ VOLTAGE CONVERTER
50d
FREQUENCY SETTING UNIT

FIG. 16

FIG. 17


1-4 ATOMIC OSCILLATOR
60
FREQUENCY DIVIDER (1/2)
TO EXTERNAL DEVICES
20 RF SIGNAL SYNTHESIZER
OSCILLATION SIGNAL 20 MHz
23 PLL
23a
23b
23c
PD
VCO
6.84 GHz
23d
1/N
10
21 FREQUENCY SYNTHESIZER
21c
21b
VCXO
DDS
LPF
LO
IF
MIXER
5.31...MHz
24
RF
CONTROL VOLTAGE
50
40 FREQUENCY CONTROLLER
LOW-FREQUENCY SIGNAL (155 Hz)
41
LOW FREQUENCY OSCILLATOR
FREQUENCY SETTING UNIT
RF SIGNAL 6.84 GHz ±5.31...MHz
RESONANCE DETECTION SIGNAL
30
44
43
42
INTE-GRATOR
SYNCHRONOUS DETECTOR
AMPLI-FIER
ATOMIC RESONATOR

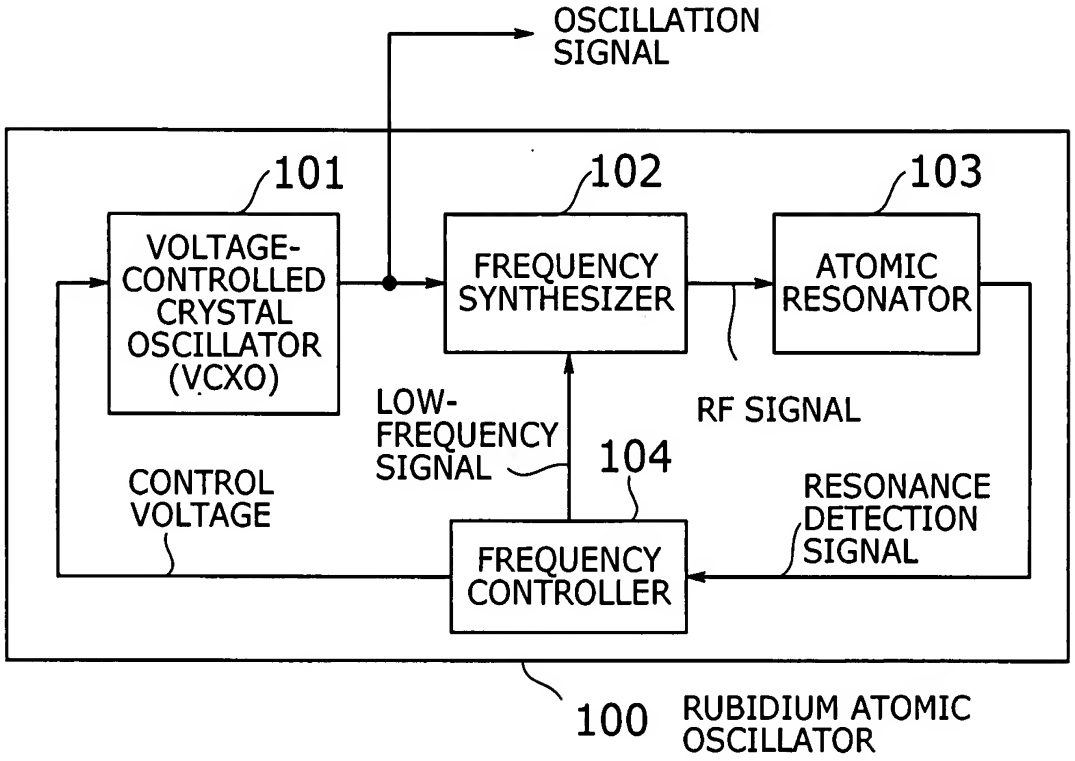


FIG. 18

PRIOR ART

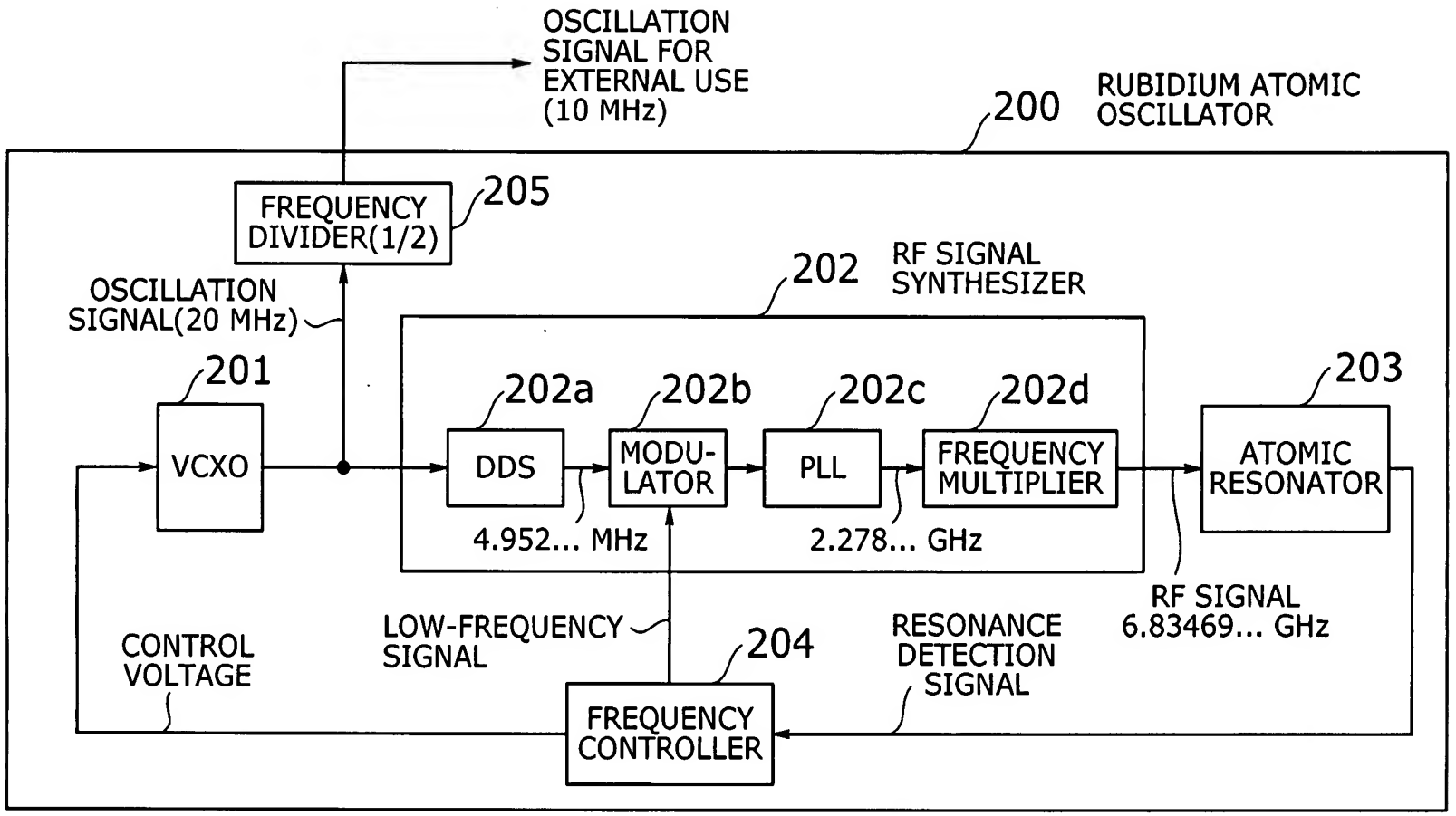


FIG. 19

PRIOR ART